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TEST OF TOTAL RECIRCULATION, JET FLOW AND VACUUM OF A HeO_2 HELMET SUBMITTED BY THE USS KITTIWAKE

25 MARCH 1948

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U. S. NAVY EXPERIMENTAL DIVING UNIT

NAVAL GUN FACTORY

WASHINGTON, D.C.

Test of
Total Recirculation, Jet Flow and Vacuum
of a
HeO_2 Helmet
Submitted by the
USS KITTIWAKE

G.G. MOLUMPHY
Commander, USN
Officer in Charge

OBJECT

The object of this test is to evaluate the vacuum, jet flow and total recirculation of a HeO_2 helmet submitted by the USS KITTIWAKE.

METHOD

The helmet was manufactured by the Diving Equipment and Salvage Company, Milwaukee, Wisconsin. The helmet number was 2992 and it was manufactured on 17 August 1945.

All tests were made under atmospheric pressure. Two identical tests were made on the helmet. The first was made c the helmet as received. No adjustment or cleaning was done. The second test was made after a number 74 drill was passed through the jet crifice. The cannister was empty. Two methods of measuring total recirculation were used.

Air was used in all tests except in the determination of jet flow before and after passing of the number 74 drill through the jet crifice. Oxygen was used in these cases.

The following precedure was used in the total recirculation tests: The pressure over bottom was varied from 25 lbs/in^2 to 100 lbs/in^2 in 25 lbs/in^2 increments. The recirculation was measured by leading the hose from the discharge duct of the helmet into a spircmeter. This hose was 3/4 inch inside diameter and was approximately eight feet long. The end connected to the helmet w·s fitted with a nipple which in turn was fitted to a soft sponge gasket. This was held against the discharge duct manually when a recirculation flow reading was desired. Readings of the spirometer were made before and after definite intervals, determined by a stop watch. The spirometer's identification number was 000200.

The other recirculation test followed the same procedure except that the cannister was removed and the hose was placed over the Venturi tube.

The jet flows were made by removing the Venturi tube and placing a 3/16 inch inside diameter hose over the jet discharge. This flow was exhausted into the spirometer as before. Air was supplied to the jet at various pressures over bottom as in the recirculation test.

The jet flow was again taken with oxygen. A small hose was placed over the discharge jet as before and discharged into a Sargent wet test meter. The jet crifice was then reamed out with a number 74 drill, and the flow again was taken in the same manner. The meter identification number was 000280.

The vacuum was taken by inserting a sponge rubber ball fitted with a manometer connection into the entrance of the recirculation system. This was done with and without the cannister. The vacuum total recirculation and jet flow were taken with 25, 50, 75 and 100 lbs/in^2 over bottom supplied to the Venturi jet.

All flows are given in liters per minute except when indicated otherwise.

DISCUSSION OF RESULTS

The results of the tests show that the vacuum, jet flow and total recirculation are below those normally found in a HeO_2 helmet. The vacuum and the total recirculation are dependent on jet flow, assuming that the system is in normal operating order. It was found that the jet flow was about 20% below the normal range of 0.40 to 0.45 ft^3/min with oxygen being used. Jet flows were taken with both air and O_2. The air jet flows were somewhat higher because air is less dense. The molecular weight of air is 29 and that of O_2 is 32.

The vacuum produced was about half of that normally found in a normal operating recirculating system. The vacuum produced was the same with or without the cannister. Although the vacuum is not an absolute method of determination of the operation of the system. it is an indirect method of measuring recirculation. A vacuum of about 25 centimeters of water with 100 lbs/in^2 over bottom supplied to the jet is an indication of a HeO_2 recirculating system in good operating condition. The vacuum produced by air or HeO_2 is almost identical. This was proven in previous experiments. The vacuum produced was the same with or without the cannister.

The reduction in jet flows produced an adverse effect on recirculation. It was reduced from 25 to 35% at atmospheric pressure. This would not be strictly true in depths greater than atmospheric. The ratio of total recirculation to jet flow is about 7 or 8 to 1, with this ratio rising slightly

with depth. This occurs with a HeO_2 mixture of about 19% oxygen. Parallel tests were made with air and HeO_2 mixture at various depths so that air results can be translated in terms of HeO_2 mixtures.

Attention is invited to the two methods of obtaining recirculation flows. There is considerably more recirculation when the flow is measured with the cannister removed and the hose placed over the Venturi tube. This is to be expected since the turbulence and friction encountered in the passage of gas through the cannister is eliminated. The continuity of flow is also maintained.

In these experiments, the cannister was empty. With Shell Natron, the effect of this friction and turbulance would be accentuated. In previous experiments it was found that the placing of Shell Natron in the cannister reduced the recirculation flow about 10% when air was used at atmospheric pressure. The same hose was used to the spirometer in both tests, and the friction loss due to this cause would be about the same. In view of the above, it would be reasonable to assume that the actual recirculation is somewhere between these two recirculation flows.

After a number 74 drill was passed through the jet crifice, the data obtained from subsequent tests was erratic. This data was discarded. The jet was disassembled. Solidified particles of pipe dope were found between the screen and the jet crifice. The screen was free of particles. The pipe dope was scraped out and the parts washed in carbon tetrachloride. Following this procedure, the test was repeated.

The jet flow increased to 0.424 ft^3 of oxygen per minute at 50 lbs/in^2 over bottom pressure. This is within the normal operating range of 0.40 to 0.45 ft^3/min. The vacuum was doubled with 24 cm of water differential produced. This is near the normal vacuum.

The total recirculation rose considerably and was near the values obtained in similar tests with the system in good operating order.

The drill passed through the crifice jet with ease. No metal particles were reamed out. It appeared as if the excess dope used to make the joint had dried and plugged the jet intermittently. The screen appeared clean. After the jet and the other parts were washed with carbon tetrachloride, the recirculating system acted consistently.

If jet and recirculation flows are normal at atmospheric pressure, it can be assumed that performance will be satisfactory at various depths. The ratio of recirculation to jet position with respect to the mouth of the Venturi affects the characteristics of the system at atmospheric pressure. However, at depths over 150 feet, there is little difference in any position of the jet from flush to a point 1/4 inch away from the mouth of the Venturi tube.

In this test the face to face dimension of the casting was 2 1/16 inch. This would place the jet tip 1/16 inch away from the mouth of the Venturi tube. The discharge edge of the Venturi tube was slightly dented. However, this would not affect the performance of the system to any appreciable extent.

From previous experiments, it has been found that the jet delivery of oxygen at a rate of 0.40 ft^3 to 0.45 ft^3 per minute at atmospheric pressure will deliver about 0.25 ft^3/min of HeO_2 mixture, 19.5% 02 at a depth of 225 feet. The total recirculation would be about eight times this value or approximately 2 ft^3/min. This is true with the Shell Natron in good condition.

It is felt that the evaluation of either the vacuum or jet flow would be a good indication of the operation of a HeO_2 recirculation system. In the comparison of the two methods, the vacuum test is more expeditious from standpoints of simplicity of test and the efficiency of the system. This test requires but a water manometer connected by tubing to some object that fits the entrance, such as a sponge rubber ball. If air or a HeO_2 mixture is supplied to the jet at 100 lbs/in^2 over bottom, the water differenti-l should be about 20 to 25 contimeters. At 50 lbs/in^2 supplied to the jet, the water differential should be about 10 to 12 centimeters. Since the operation of such a system is dependent on the rarefaction of the gas in back of the jet which in turn causes flow, the vacuum in a fairly good and simple method of checking the operation of it. It would at least reveal gross malfunctions.

The evaluation of jet flow requires a meter of fair accuracy. Although the flow may be adequate, a corresponding recirculation need not necessarily follow. There may be an obstruction in the system or poor positioning of the jet with regard to the mouth of the Venturi tube. There may also be a deviation of the jet stream from the center of the tube caused by a crooked jet. The latter is quite possible if the jet is dropped or struck accidentally. In both methods, it must be emphasized that these are but an indirect method of measuring recirculation.

It must be remembered that a small decrease in jet flow causes a large decrease in vacuum. This however does not cause a corresponding decrease in recirculation.. This is shown by the data in this test. The position of the jet with regard to the Venturi tube also affects the vacuum. However, this difference is negligible at depths over 150 feet.

Utmost care should be used when the joint is made between the jet and the fitting containing the screen. Since the faying surfaces are of brass it is felt that the use of pipe dope is unnecessary. If used at all, only a slight amount on the male thread is sufficient. Portions of the fittings between the jet and screen should be serupulously clean. Even very small particles such as powder will tend to entrap succeeding particles.

If the action of a system is erratic, the jet and screen should be disassembled and washed in carbon tetracholride or a smiliar liquid. A number 74 drill should be passed through the jet crifice before every helium dive in accordance with the Bureau of Ships Diving Manual.

CONCLUSIONS AND RECOMMENDATIONS

The vacuum, total recirculation and jet flow of this helmet was below that normally found in helmets in good operating condition.

The jet crifice was evidently of correct diameter since the number 74 drill went in easily and no metal was reamed out.

The erratic behavior of the system after the drill was passed through the jet crifice was due to the solidified pipe dope particles between the screen and the crifice. When disassembled and washed with carbon tetrachloride, the data obtained was consitent.

It is recommend that a number 74 drill be passed through the jet crifice and the strainer and nozzles inspected each time a helmet is used. Strict compliance with the instructions contained in paragraphs 4, 5, and 6, page 227, Bureau of Ships Diving Manual, will provide a-equate upkeep and inspection.

Air can be used as a fairly good check of recirculation performance in the HeO_2 helmet since parallel tests with HeO_2 have been made up to a depth of 223 feet.

Measuring the vacuum is the most simple and dependable method of checking operation of a HeO_2 recirculation system. Jet flow may also be used but it is based on the assumption that the entire system is in normal operating order. By itself, it does not reveal gross malfunctions.

If pipe dope is used at all in the making up of the joint between the jet and the fitting containing the screen, only a slight amount on the male thread is sufficient.

In the determination of vacuum, either air or HeO_2 can be supplied to the jet.

DATA SHEET

18 March 1948 - HeO_2 Helmet Test from USS KITTIWAKE. Air used except as noted. Condition of Venturi tube good, one slight dent.

Face to Face dimension of casting: 2 1/16 inches.

Helmet No.: 2992. Manufactured by: Diving Equipment and Salvage Company, Milwaukee, Wisconsin.

Date manufactured: 8-17-45

Cannister empty. Data of helmet as received.

Pressure over bottom #/in^2		25	50	75	100
Vacuum with cannister cm/H_2O		3.6	6.0	9.2	12.8
Vacuum without cannister cm/H_2O		3.6	6.0	9.2	12.8
Recir. with cannister - L/min		54.3	81.4	103.5	120.9
Recir. without cannister hose slipped over Venturi tube - L/min		66.0	98.3	124.8	145.1
Jet flow (air)	- L/min	6.6	10.65	14.85	19.05
	- Ft^3/min	.233	.376		
Jet flow (O_2)	- L/min	5.78	9.45		
	-Ft^3/min	.204	.334		

DATA AFTER PASSING #74 DRILL THROUGH JET ORIFICE

Pressure over bottom #/in^2		25	50	75	100
Vacuum with cannister cm/H_2O		6.2	11.5	17.4	24.0
Vacuum without cannister cm/H_2O		6.2	11.5	17.4	24.0
Recirc. with cannister - L/min		85.6	108.5	127.0	148.0
Recirc. without cannister hose slipped over Venturi tube - L/min		104.0	135.0	163.0	190.0
Jet flow (air)	- L/min	8.84	14.2	19.9	25.4
	- Ft^3/min	0.312	0.503	0.702	0.898
Jet flow (O_2)	- L/min	7.76	11.98		
	- Ft^3/min	0.274	0.424		

Drill went in easily. Evidently no metal was reamed out. Readings after this were erratic. Jet was disassembled. Solidified pipe dope was found between screen and orifice. Parts were washed in carbon tetrachloride and reassembled. All data in second part of test were taken after parts were washed in carbon tetrachloride.